REPORT #
RRTAC 88-6

Reclamation Research Annual Report — 1987

Heritage Fund

Alberta

LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

Report No. RRTAC 88-6

RECLAMATION RESEARCH

ANNUAL REPORT - 1987

Prepared by

The Reclamation Research Technical Advisory Committee

for the

ALBERTA LAND CONSERVATION AND RECLAMATION COUNCIL

1988

STATEMENT OF OBJECTIVE

This report is intended to provide government and industry staff with up-to-date technical information to assist in the development of guidelines and operating procedures. The report is also available to the public so that interested individuals similarly have access to the best available information on land reclamation topics.

ALBERTA'S RECLAMATION RESEARCH PROGRAM

The regulation of surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a Chairman from the Department of Forestry, Lands and Wildlife. Among other functions, the Council oversees programs for reclamation of abandoned disturbances and reclamation research. The Reclamation Research Program was established to provide answers to the many practical questions which arise in reclamation. Funds for implementing both the operational and research programs are drawn from Alberta's Heritage Savings Trust Fund.

To assist in technical matters related to the development and administration of the Research Program, the Council appointed the Reclamation Research Advisory Committee (RRTAC). The Committee first met in March 1978 and consists of eight members representing the Alberta Departments of Agriculture, Energy, Forestry, Lands and Wildlife, Environment and the Alberta Research Council. The Committee meets regularly to update research priorities, review solicited and unsolicited research proposals, arrange workshops and otherwise act as a referral and coordinating body for Reclamation Research.

Additional information on the Reclamation Research Program may be obtained by contacting:

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1. INTRODUCTION

The regulation of surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a chairman from the Department of the Environment and two deputy chairmen from the Department of Forestry, Lands and Wildlife. Among other functions, the Council oversees programs for reclamation of abandoned disturbances and reclamation research. The reclamation research program was established to identify the most efficient methods for achieving acceptable reclamation. Funds for implementing both the operational and research programs are drawn from Alberta's Heritage Savings Trust Fund.

To assist in technical matters related to the development and administration of the research program, the Council appointed the Reclamation Research Technical Advisory Committee (RRTAC). The Committee first met in March 1978 and consists of eight members representing the Alberta Departments of Agriculture, Forestry, Lands and Wildlife, Environment and the Alberta Research Council. The Committee meets regularly to update research priorities, review solicited and unsolicited research proposals, arrange workshops and otherwise act as a referral and co-ordinating body for reclamation research.

RRTAC develops research under four major program areas: Plains Coal, Mountains and Foothills Coal, Northeast Oil Sands and Oil and Gas Disturbances. Most of Alberta's industrial activity occurs in the three major biophysical regions: the **Plains**, where most of the Province's agricultural land is located, the **Mountains and Foothills** where recreation, forestry, wildlife and watershed values are predominant, and **Northeast Alberta**, where wildlife and forestry values exist; whereas, oil and gas related developments are widely distributed througnout the province.

Coinciding with these regions are three major disturbance types:

1. Plains: Coal mines operated in conjunction with electrical generating plants,
2. Mountains and Foothills: Metallurgical coal mines and high quality thermal coal for export, and
3. Northeast Alberta: Oil sand mining and extraction facilities.

While it is expected that research results will often have province-wide application, the division of the program among the three biophysical regions has proven helpful in identifying priorities and directions for the research program.

The objectives of the research projects are:

1. To develop methods that will make reclamation a more efficient and effective process;
2. To provide scientific data to enable sound decision making in the regulatory and operational reclamation stages; and
3. To provide scientific data to evaluate the effectiveness of reclamation guidelines and criteria.

In addition, every effort is made to involve industry in management and funding of the research to ensure the projects address real field concerns. Cooperation with industry facilitates agreement on reclamation research priorities and early implementation of required changes in operations and planning.

RRTAC research projects are trials for new technologies, and new proposals are reviewed and rated on their adherence to priorities, likelihood of success and competence of researchers. Throughout the review process, the key question is: "Would this technology make reclamation in Alberta a more efficient process?"

Upon project completion a final report is submitted. Some final reports are published intact as RRTAC Reports and released to the public. Section 3.6 provides a listing of available reports. Others are held pending their inclusion in comprehensive RRTAC reports.

Additional information on the Reclamation Research Program may be obtained by contacting:

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2. THE RESEARCH PROGRAM

Following is a summary of the most recent research projects as of March 31, 1988. Budget details are given in Section 3.2. Information on previous projects is given in Section 3.1 and in previous annual reports.

2.1 PLAINS COAL RECLAMATION RESEARCH PROGRAM

The Plains Coal Reclamation Research Program (PCRRP) has been designed by the provincial government and members of the coal industry to answer questions relating to groundwater and soil reconstruction in plains coal mining zones. Efforts are focussed in two main areas:

1. Soil reconstruction will indicate how to rebuild agricultural soils after mining, and
2. Hydrology will describe what happens to groundwater during mining and after reclamation, and how to rebuild the landscape to maximize the agricultural potential.

The program has been jointly designed and managed by the provincial government and coal industry personnel. The projects are also funded by both industry and government. For example, Alberta Power Limited, Luscar Ltd., Manalta Coal Ltd. and TransAlta Utilities Corporation constructed the test plots at the Battle River and Highvale sites while research and maintenance activities for the Soil Reconstruction and Hydrology projects are supported by the provincial government.

2.1.1 Reclamation Objectives

To return crop land to pre-mining levels of capability. Capability includes both agricultural and hydrologic capabilities.

2.1.2 The Problem

Coal is surface mined in two major zones in Alberta: the Ardley Zone running southeast from Mayerthorpe to Red Deer and the Horseshoe Canyon Zone which runs parallel and to the east from Barrhead through Camrose to Drumheller (Figure 1). The Ardley Zone is surface mined near Lake Wabamun to provide coal to the Wabamun, Sundance, and Keephills power plants. An

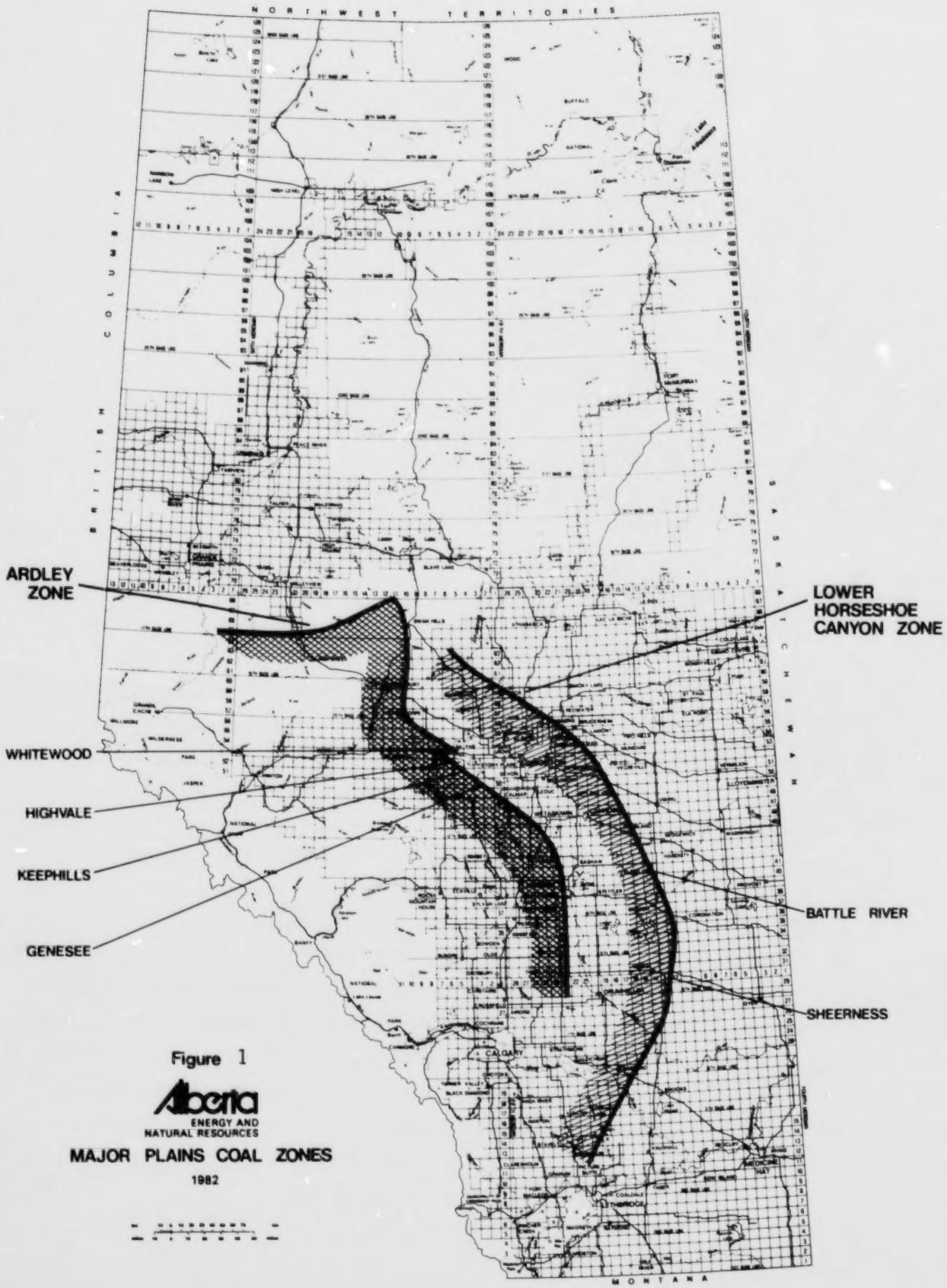


Figure 1

Alberta
ENERGY AND NATURAL RESOURCES

MAJOR PLAINS COAL ZONES

1982

additional power plant, Genessee, is under construction and will extend mining southward to the town of Genessee. The Horseshoe Canyon Zone is mined on either side of the Battle River between Forestburg and Halkirk. These mines supply tne Battle River Generating Station. Another power plant and mine have been developed to the south of Sheerness.

Plains coal seams are usually overlain by bedrock which contain a high proportion of swelling clays. When exposed to the elements, the bedrock shales and sandstones break down into a material that is sticky when wet and very hard when dry. This severely hinders plant growth and agricultural operations. Above the bedrock lie glacial deposits which are usually free of the most adverse properties of the bedrock though they lack the plant nutrients and organic matter which are characteristic of the overlying topsoil.

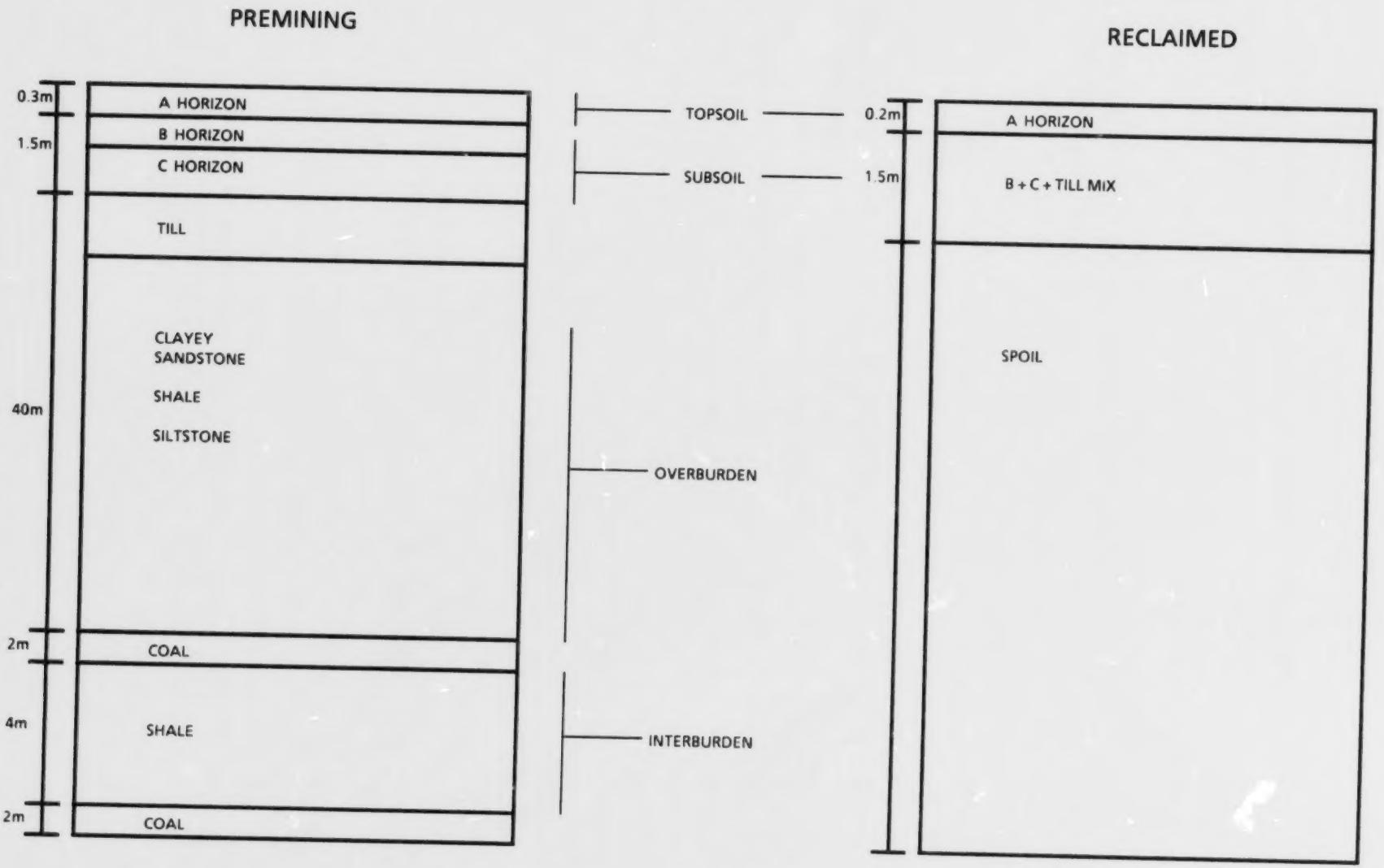
Rebuilding a soil profile is one of the major problems in cropland reclamation in Alberta. A soil must be built on levelled overburden which will have similar capability to the original soil. Existing evidence indicates that placing topsoil and a buffering material over the spoil is the most efficient method for achieving this goal (Figure 2). However, we do not know exactly how much capping material is needed in order to bring back the original level of agricultural capability. Also, when topsoils or subsoils are in short supply, other amendments may be useful in soil building. In addition to soil reconstruction, certain agricultural practices like green manuring and legume cropping may help rebuild the soil.

In many plains areas, the coal seams are the major source of domestic water. What will happen when the coal is removed and overburden fills the mined-out pit? The behaviour of the post-mining groundwater system will affect water users and could influence future agricultural potential. However, prior to the Reclamation Research Program little was known about the effects of surface mining on groundwater in Alberta.

2.1.3 Research Approach

Mining in the Ardley and Horseshoe Canyon Coal zones involves two different sets of soils, overburden and climate. Also, soil reconstruction and groundwater cannot be studied in isolation. For example, if after mining,

FIGURE 2 - GENERALIZED PROFILES



a saline watertable re-establishes within a foot of the soil surface, the topsoil, regardless of its original quality, will quickly become unsuitable for crops. In both the Ardley and Horseshoe Canyon zones the best methods of reconstructing soils are being identified and at the same time, mining effects on groundwater are being studied.

By combining the results of these experiments, we will develop a picture of how mined landscapes work and how they can be designed to ensure the return to their original value.

These projects are installed both at the Highvale and Battle River mining areas. Both are designed for five years of intensive study with the possibility for further monitoring beyond that period.

2.1.4 Soil Reconstruction

Battle River Soil Reconstruction Project - L. Leskiw, Can-Ag Enterprises Ltd.

Highvale Soil Reconstruction Project - L.A. Panek, Monenco Consultants Ltd.

Grain and forage yields are being evaluated on a series of soil reconstruction plots at the Battle River (Figures 3a to f) and Highvale (Figures 4a to c) mining areas. Treatments include: depth of subsoil (0 to 3 m thicknesses) over sodic spoil, use of bottom asn and gypsum as amendments to sodic spoil, and reconstruction of solonetzic soils. Salt movement over spoil slopes is also being studied. The project began in 1979 at Battle River and plot construction was completed at Highvale in 1982.

Status: Cropping and soil sampling began at Battle River in 1982 and at Highvale in 1983. Five-year summary reports are being prepared for both studies. A less intensive monitoring program will continue at both sites.

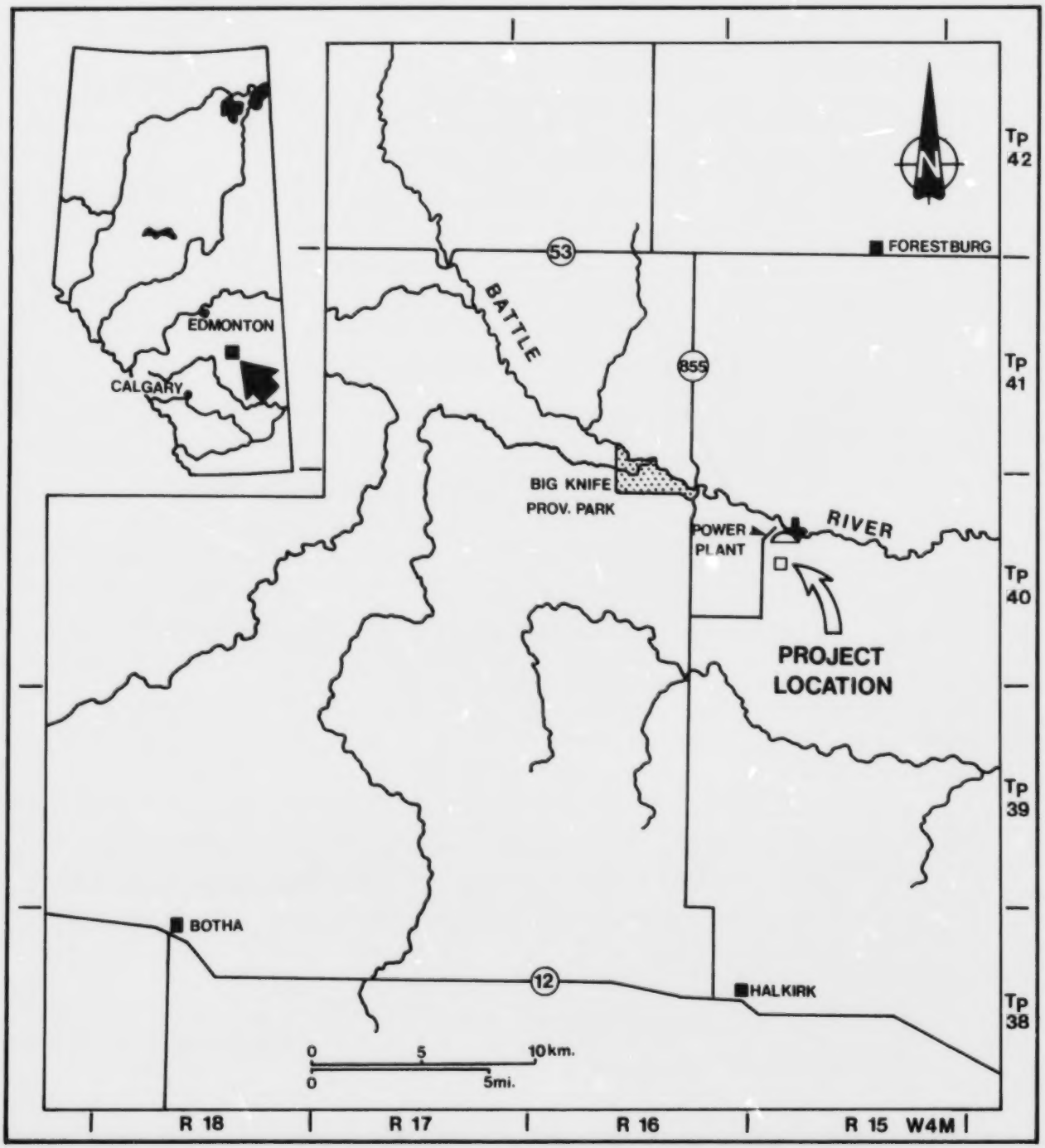


FIGURE 3a. LOCATION MAP, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

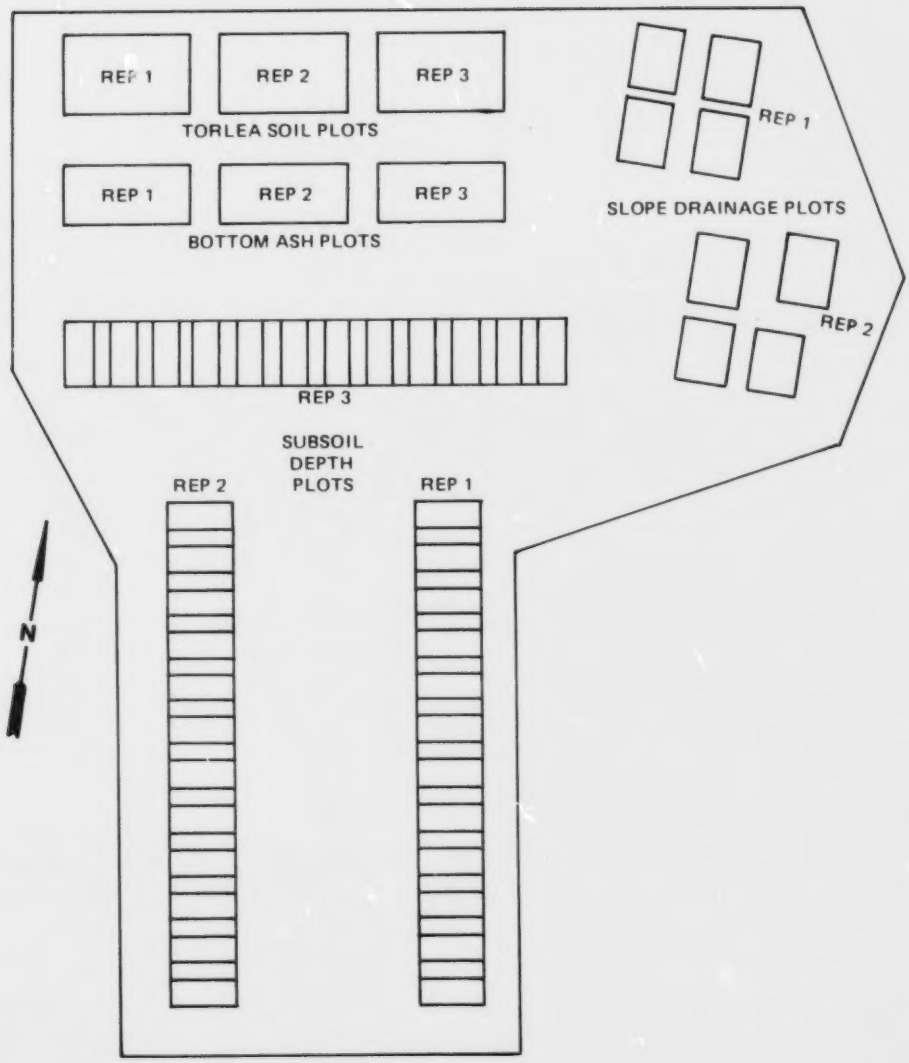


FIGURE 3b COMPOUND LAYOUT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

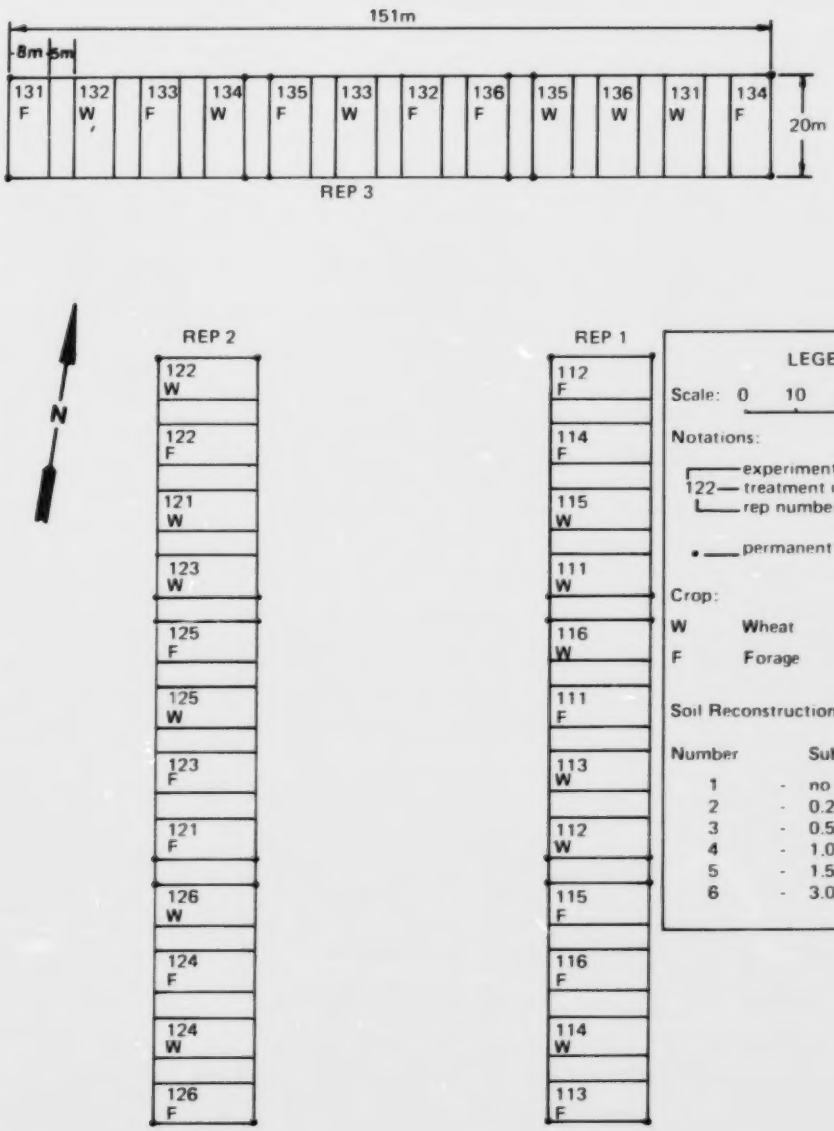


FIGURE 3c. PLOT LAYOUT – SUBSOIL DEPTH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

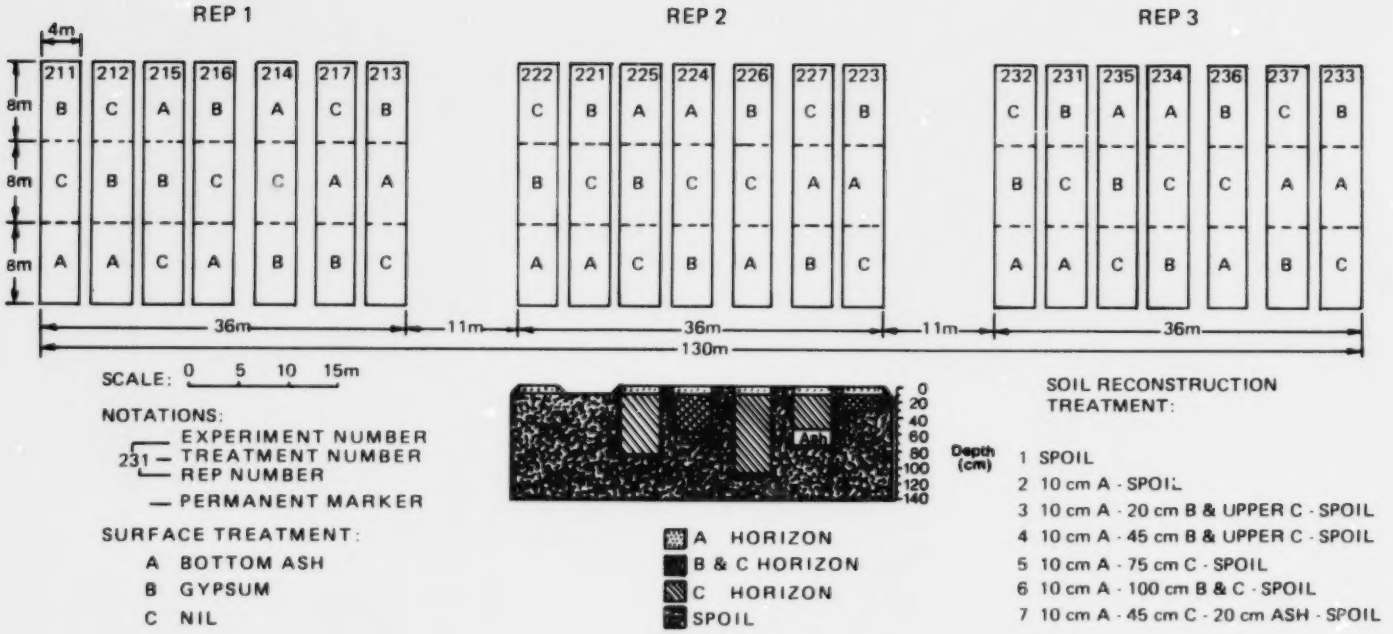


FIGURE 3d. PLOT LAYOUT – TORLEA SOIL EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT

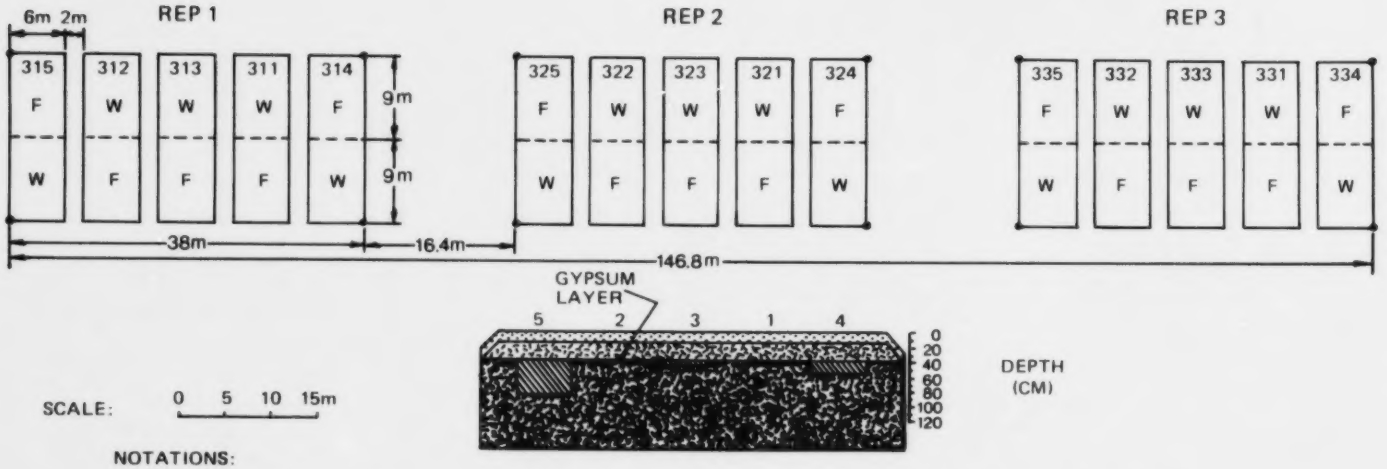
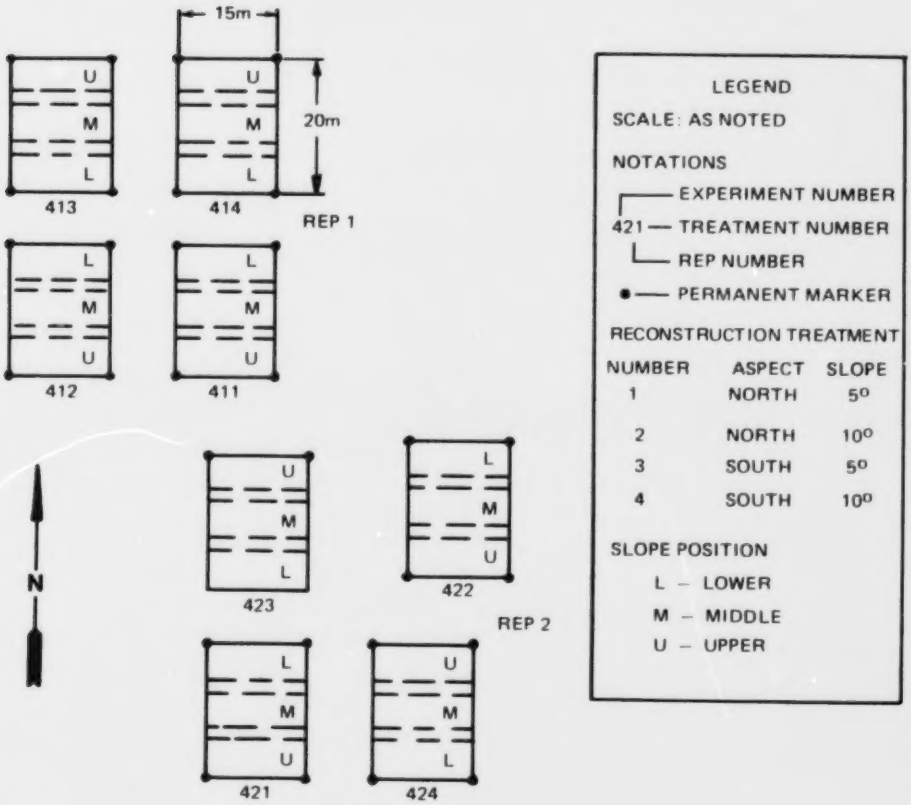


FIGURE 3e. PLOT LAYOUT – BOTTOM ASH EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT



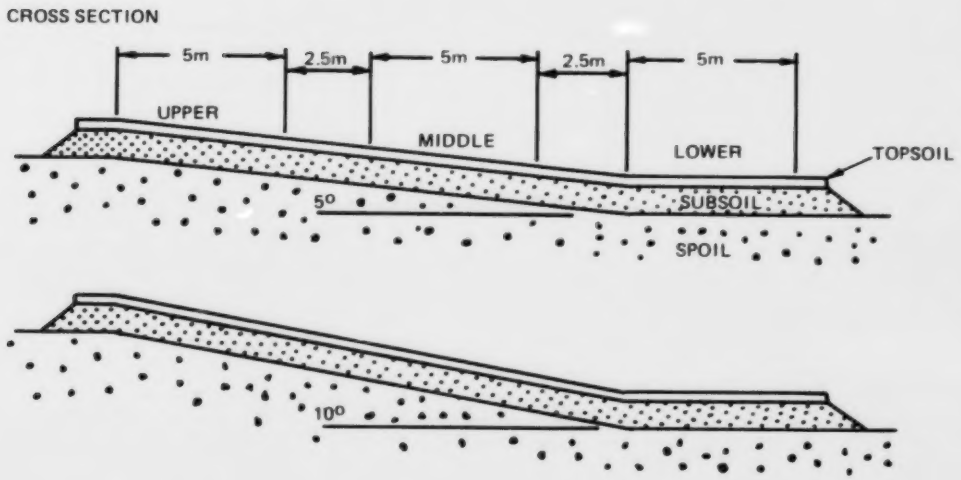
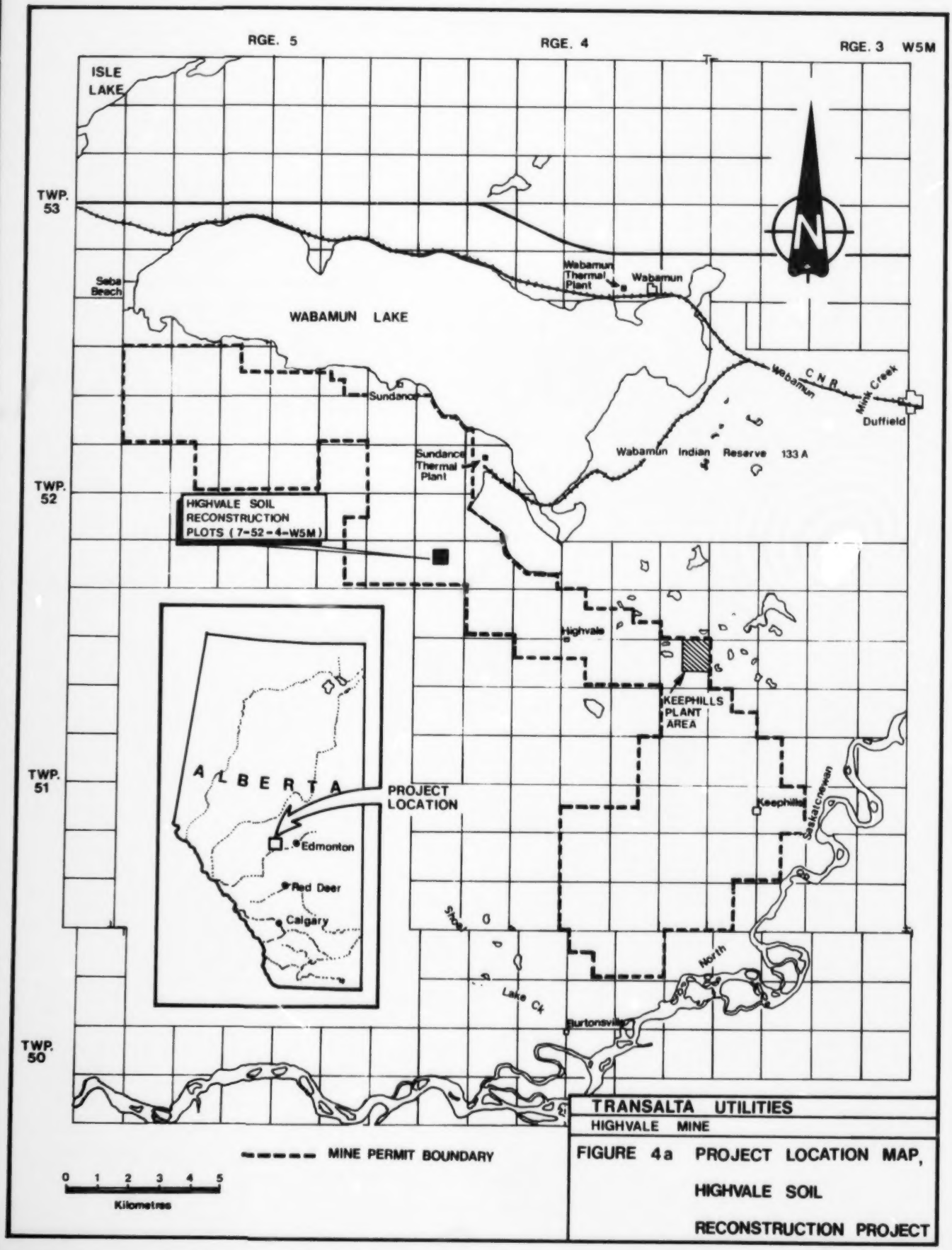
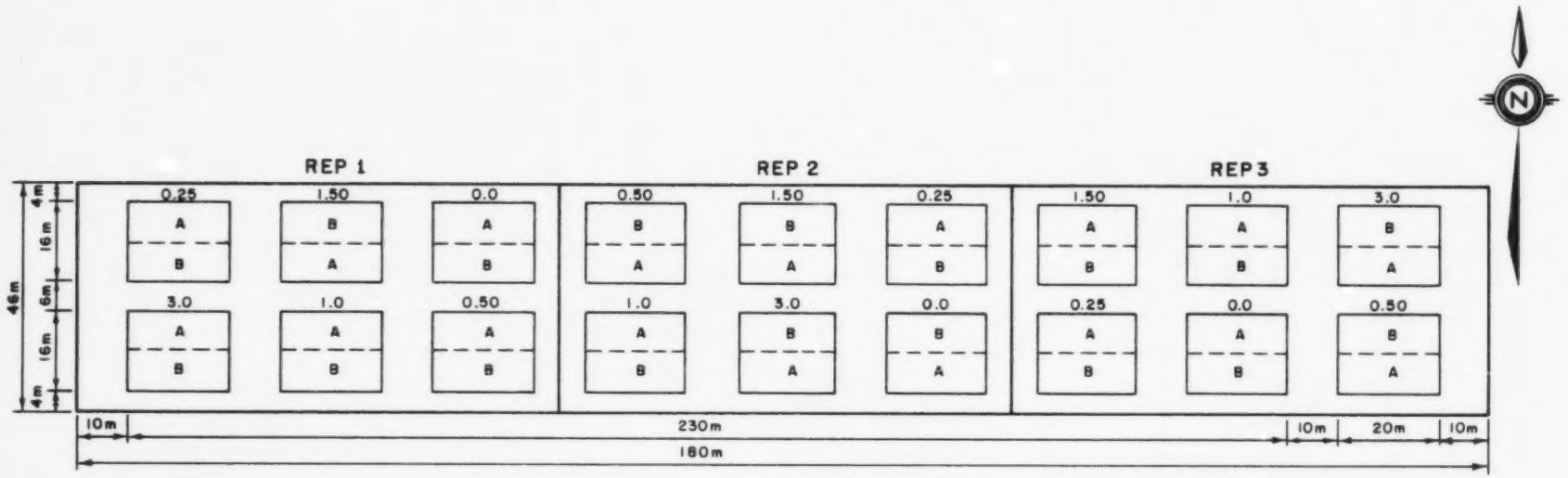


FIGURE 3f. PLOT LAYOUT – SLOPE DRAINAGE EXPERIMENT, BATTLE RIVER SOIL RECONSTRUCTION PROJECT


RGE. 5
RGE. 4
RGE. 3 W5M
ISLE LAKE
TWP. 53
TWP. 52
TWP. 51
TWP. 50
Seba Beach
WABAMUN LAKE
Wabamun Thermal Plant
Wabamun
C N R
Mink Creek
Duffield
Sundance
Sundance Thermal Plant
Wabamun Indian Reserve 133 A
HIGHVALE SOIL RECONSTRUCTION PLOTS (7-52-4-W5M)
Highvale
KEEPHILLS PLANT AREA
Keephills
Saskatchewan
ALBERTA
PROJECT LOCATION
Edmonton
Red Deer
Calgary
Lake
Burtonsville
North
MINE PERMIT BOUNDARY
0 1 2 3 4 5
Kilometres
TRANSALTA UTILITIES
HIGHVALE MINE
FIGURE 4a PROJECT LOCATION MAP, HIGHVALE SOIL RECONSTRUCTION PROJECT



A - ALFALFA (Rambler) AND BROMEGRASS (Charlton)
B - BARLEY (Klondike)
0.0 NO SUBSOIL
0.25 0.25m SUBSOIL
0.50 0.50m SUBSOIL
1.00 1.00m SUBSOIL
1.50 1.50m SUBSOIL
3.00 3.00m SUBSOIL

FIGURE 4b.

HIGHVALE SOIL RECONSTRUCTION PROJECT

SUBSOIL EXPERIMENT
LAYOUT

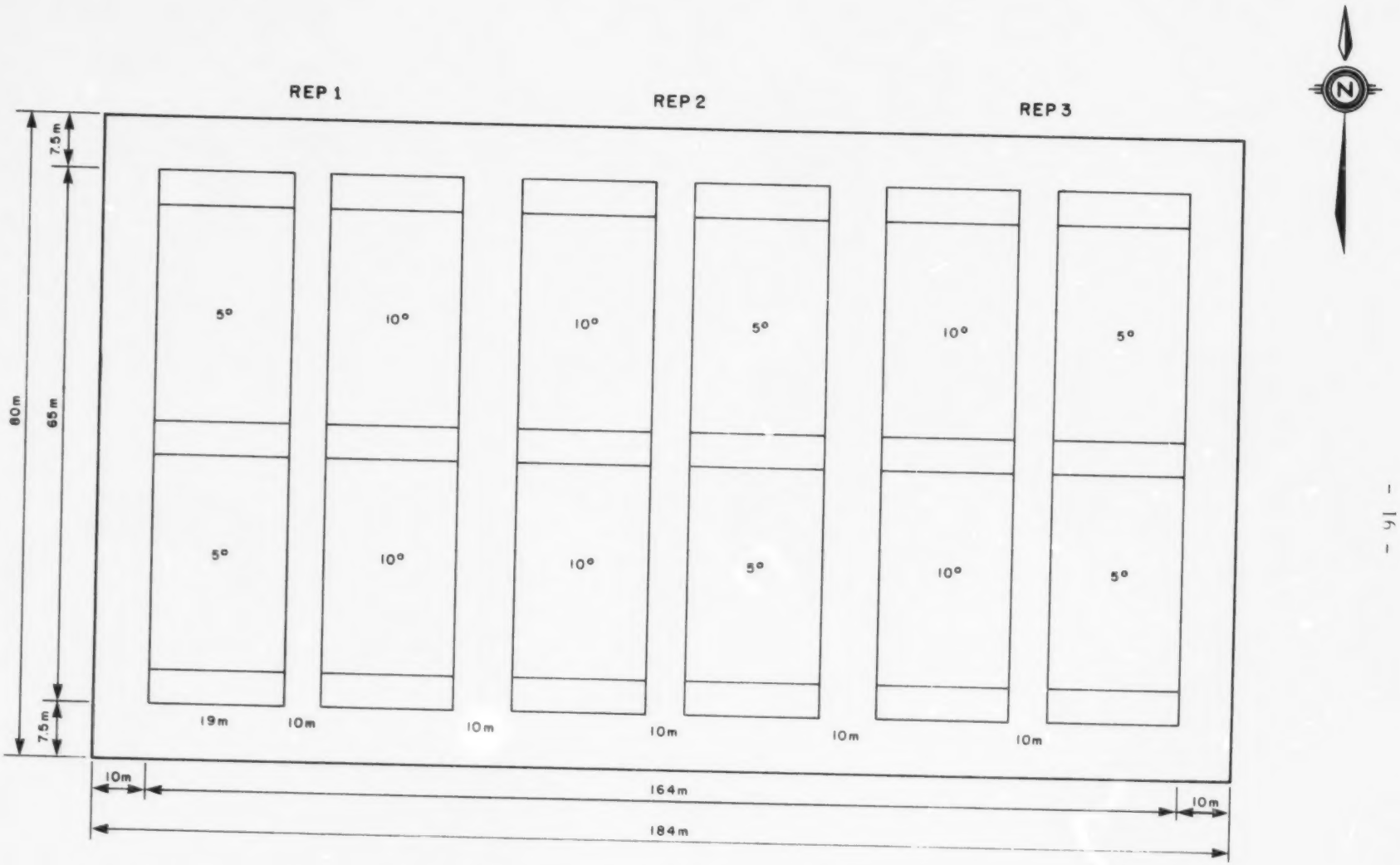


FIGURE 4c.
HIGHVALE SOIL RECONSTRUCTION PROJECT
SLOPE EXPERIMENT
LAYOUT
(NOT TO SCALE)

FORAGE CROP

2.1.5 Hydrology

Plains Hydrology and Reclamation Project - S.R. Moran, Alberta Research Council

This study examines the impacts of surface mining on the regional groundwater, geology and soils. The main objectives include the identification of:

1. Changes in groundwater quality and quantity after mining;
2. sources and release rates of groundwater contaminants (mainly salts);
3. changes in distribution of groundwater after mining (will the groundwater carry salts to the surface, will the watertable drop or will it re-establish at pre-mining levels); and
4. surface stability after mining (subsidence, piping).

Critical groundwater and geologic parameters will be identified which should allow us to predict the "reclaimability" of a site prior to mining. This project began in 1979 and is being conducted at the Battle River and Highvale sites.

2.1.5.1 Phase 1. The first five years of the project (1979 to 1984) were devoted to:

1. Instrumentation to collect basic data on the geology, subsurface water, and soils of the Battle River mining area;
2. Mapping of the soil and geology of the area;
3. Analysis of properties of overburden materials, and chemistry and movement of subsurface water;
4. Experimental studies on physical and chemical weathering of overburden materials;
5. Computer modelling of mine-affected groundwater flow systems;
6. Evaluation of hydrogeology and chemistry of mine spoil at both the Highvale and Whitewood Mines;
7. Completion of infiltration tests in the spoil;
8. Development of a preliminary procedure to relate weathering data to groundwater chemistry in spoil;

9. Installation of field scale experiments at both sites to test the validity of the overall predictive framework on salt yield of the overburden.

The following represents a partial list of the conclusions from the first phase of the project:

1. Soluble salts already present in abundance in the overburden are sufficient to produce groundwater in spoil that has chemical quality substantially reduced relative to premining aquifers.
2. Weathering of overburden has very limited potential to substantially increase the salt reservoir within reclaimed landscapes.
3. There appears to be no justification for additional selective handling and placement of soil and overburden material over and above that currently practiced as a means to improve chemical quality of groundwater or to decrease potential for soil salinization.
4. There was no evidence of perching of water near the land surface, either within the subsoil or at the interface between the subsoil and spoil. (This conclusion has subsequently changed as a result of continued observations during Phase II.)
5. Discharge of spoil groundwater to surface streams should not result in measurable deterioration of chemical quality of receiving streams.
6. In some settings, discharge of spoil groundwater can significantly degrade chemical quality in shallow groundwater beneath unmined terrain adjacent to reclaimed areas at least 1.5 km from the mine boundary.
7. Mining will destroy all aquifers located above the base of the mine. Except in very rare cases, replacement aquifers cannot be re-established within the mine spoil. In some areas of the Lower Horseshoe Canyon Coal Zone, alternative aquifers can be exploited beneath the base of mining.

8. Reconstructed soil landscapes are characterized by a higher degree of small-scale variability and lower degree of large-scale variability than are unmined soil landscapes.
9. The capability for agricultural production of reconstructed landscapes can be described and evaluated by a system that is essentially equivalent to that used in unmined landscapes.
10. Using the capability rating system that was developed by the project, it was determined that reconstructed soil capability was generally equivalent to the premining soil capability. Post-mining capability reflects a more "average" capability as compared to the relatively higher and lower capability ratings attached to soil units in the premining landscape.

2.1.5.2 Phase II. The objectives of the second phase of the project (1984 to 1987) were reformulated from the objectives of Phase I to reflect the knowledge gaps identified in Phase I. The three subobjectives of this second phase focus on:

1. Design and construction of reclaimed landscapes that maximize long-term agricultural capability by minimizing potential salinization through the management of water in the landscape;
2. Assessing changes in agricultural capability and productivity of reclaimed landscapes on a long-term basis; and
3. Refining our understanding of groundwater chemistry and recharge in reclaimed landscapes, as well as groundwater-induced salinization effects adjacent to reclaimed areas.

Work during 1984-85 focused on installation of intensive instrumentation in a number of slope and depressional settings in reclaimed and analogous unmined sites, primarily in the three mines at the Battle River site. Only preliminary data were accumulated from this new instrumentation.

During 1985-86 work focused on completion of instrumentation at field capillary study sites and along slope profiles in reclaimed settings, and at unmined reference slope sites. In addition, an experimental site to evaluate vertical salt migration above a shallow water table in a simulated spoil profile was constructed. A second set of false-colour infrared

photography was obtained, interpreted and ground checked as part of our analysis of techniques to identify distribution of soil salinity in reclaimed sites. A tracer study using bromide ion was conducted to assess tne contribution to soil salinization by lateral flow in the unsaturated zone. Instrumentation of spoil subsidence sites at Vesta and Paintearth Mines was completed. The other two major activities were monitoring of project instrumentation and continuing synthesis of results and completion of Phase I reports.

In 1986-87, data collection continued, but the major activities focused on re-synthesis of models of infiltration and groundwater recharge, salt and water movement, and surface stability in reclaimed landscapes. The following is a partial list of conclusions arising out of Phase II of the project:

1. In well-drained landscape positions in reclaimed terrain, sodium is moving downward, suggesting that the quality of reconstructed soils in these settings is improving over time.
2. In well-drained landscape positions in reclaimed terrain, bulk density is decreasing with time. It appears that a significant portion of the decrease in density occurs in the initial five to seven years following reconstruction.
3. Saline conditions develop where the water table is within about 1.0 to 1.2 m of the surface in the loamy, till-derived subsoil material that is typical of the Battle River mining area. In unmined settings in the same area, saline conditions have been observed where the water table is as much as 2.0 m below the surface.
4. Strong upward capillary transport of water and salt is limited to a zone about 0.6 m above the water table in the loamy, till-derived subsoil material that is typical of the Battle River mining area.
5. Depressions formed by differential subsidence in reclaimed landscapes contain ephemeral ponds that are potentially significant contributors to groundwater recharge during spring melt and heavy precipitation events.

6. Steady-state groundwater conditions are established in most sites in reclaimed landscapes within 10 to 15 years following mining where deep surface ponds are present and the spoil is 10 to 20 m thick.

Status: Phase II marks the completion of this major undertaking. The Alberta Research Council continues to conduct work under its own funding. Approximately 25 research reports are expected to be generated from this research project, including a summary report in the next two years. Several reports have already been released: RRTAC 86-2, 86-3, 86-4, 86-5, 86-6, 86-7, 87-9, 87-10, 87-11, 87-12, and 87-13.

2.1.6 Soil Water Interactions

Water Balance in Sodic Spoil - R. Johnson, Alberta Environmental Centre (AEC)

Work conducted by the Alberta Research Council has shown that depth of the water table in a saline sodic soil system can have a great effect on the quality of the rooting zone soil.

This study was initiated in 1986 to determine the effects of crop type, depth to groundwater and microclimate on salinity and water movement in reclaimed soils. Large lysimeters (75 cm wide x 100 cm deep) have been developed at the Alberta Environmental Centre and will be planted to annual grain (barley or wheat), forage (alfalfa) or left fallow. One half of the lysimeters will have a watertable maintained at 95 cm, the others will be free draining.

The data collected will allow development of a model that can predict soil moisture content and movement over large areas with few data inputs. This will allow land managers to predict optimum locations for crops on a reclaimed landscape and to predict the effects of those crops on soil water balance.

Status: The project is ongoing. More information is available in AEC annual reports.

2.1.7 Ash Amendments

Use of Bottom Ash as an Amendment to Sodic Spoil (83-4-LAN) - S. Landsburg, Alberta Environment

Prior to the current practice of soil salvage and replacement, surface mined land in the Plains generally reverted to waste land. This was particularly true where sodic overburden was encountered. Reclamation of these orphaned areas in the absence of suitable soil requires amendment of the sodic spoil surface. Perhaps the most promising amendment appears to be bottom ash from the nearby power plants. Earlier research indicated that this waste product possesses the ability to significantly improve sodic spoil. This project will identify, through field testing, which ash amendment rates and incorporation methods are most effective in developing at least minimal productive potential in orphaned sodic spoil.

Status: The research is completed and a final report has been published: RRTAC 87-7.

2.2 MOUNTAINS AND FOOTHILLS RECLAMATION RESEARCH PROGRAM

In 1984, The Coal Association of Canada and RRTAC initiated the jointly-funded Mountains and Foothills Reclamation Research Program (MFRRP). The program's focus is on Water Management, Soil Reconstruction, Reforestation and Wildlife Habitat Development.

2.2.1 Reclamation Objectives

1. Control of erosion on a variety of disturbances including coal mines, mineral exploration sites, coal ash pits and oil and gas sites.
2. Return of forested lands to previous levels of capability.
3. Return of wildlife range to previous levels of capability.

2.2.2 The Problem

Reclamationists in the mountains and foothills face a wide variety of conditions. While some foothill sites are characterized by subdued terrain

and moderate climate, other sites, particularly in the mountains, present steep slopes, rocky spoil and a short growing season. On these problem sites, summer droughts, chinook winds, erodible slopes and nutrient-poor soils are common.

On lower elevation foothill sites, reclamation is expected to yield forests with commercial potential while on the higher elevation mountain sites erosion control, development of wildlife habitat and recreation potential are the reclamation objectives.

Reclaimed land in the mountains and foothills will not be as intensively managed as reclaimed agricultural lands would be. Also, topsoils and subsoil layers tend to be thin and difficult to handle selectively. Nonetheless, they are a valuable source of plant nutrients. So while some mixing of horizons is inevitable, how much is acceptable? How thick should the replaced soil layer be? Other sites simply have no salvageable topsoil and reclamation must prepare the site so that a plant-soil system will develop which will perform its land use expectations without indefinite fertilization.

2.2.3 Research Approach

There are four important aspects to reclamation in the Mountains and Foothills region:

1. The creation of stable reclaimable landscapes. This includes dump design (optimal slope, angles and lengths, terracing) and pit backfilling.
2. Preservation of watershed integrity and water quality. Water flow and sediment control are of prime interest.
3. Reconstruction of a suitable growing medium for each land use. The goal is to make the best use of limited materials to improve the root zone over rocky, nutrient poor spoil.
4. Selection of suitable vegetation for each land use and proper planting to ensure survival and growth. The goal is creation of a self-sustaining cover that does not require long-term maintenance.

2.2.4 Landscape Design

Mountain and Foothill Dump Design - R.G. Chopiuk, Coal Mining Research Company

In Phase I, resloped overburden dumps in Alberta and British Columbia were surveyed to identify practical construction and resloping strategies. It was found that many, though not all dumps, were graded to shallower slopes (22 to 24%) than had been designed (27%). Operator and machine limitations were cited.

In Phase II, a number of slopes were instrumented to identify the volumes of erosional loss due to various slope angles, lengths, berms and topsoiling. After two years of monitoring, the conclusion was that there is little concern about waste dump erosion. Where erosion did occur on slopes (primarily in the first year after reclamation), there was a tendency for the materials to be quickly deposited on lower portions of the slope. There was no evidence of eroded material leaving the waste dump area.

Status: The project is completed and a final report has been published: RRTAC 87-8.

2.2.5 Watershed Design

Settling Pond Research - Phase II - B. Bietz, Beak Associates Consulting Ltd.

The purpose of this project is to establish the scientific basis for the existing water quality and quantity legislation for mines in the Eastern Slopes of Alberta and to document the source and basis for various parameters for water quality and design flows with specific reference to the Alberta East Slopes conditions.

Status: The project is completed and a final report has been published: RRTAC 87-5.

Assessing Design Flows and Sediment Discharge on the Eastern Slopes - G. Beckstead, Hydrocon Engineering Ltd.

In this study, the literature will be evaluated and a methodology selected to assess precipitation, flood flows, and sediment discharge in mountain/foothills regions of Alberta with respect to their implications for settling impoundment design, and culvert and drainage ditch sizing in coal mining developments. Also included is the design a field program to measure the most critical parameters for erosion and sediment of control structures.

Status: Phase I is completed and a final report has been published: RRTAC 87-6. Planning for Phase II which involves data collection at selected mine sites is underway.

2.2.6 Soil Reconstruction

Soil Reconstruction in Mountain and Foothill Coal Mining - L. Knapik, Pedocan Land Evaluation Ltd.

This review assembled available information to facilitate operational reclamation decisions to provide for tree growth (forestry use), shrub growth (wildlife habitat) and herbaceous cover (erosion control). This review also identified information gaps and recommended needed research.

Status: Project is completed and a final report has been published: RRTAC 87-2.

2.2.7 Revegetation

Selection of Native Grasses for Reclamation - R. Hermesh, Alberta Environmental Centre (AEC).

Many alpine and subalpine sites are difficult to reclaim simply because commercially available grasses and legumes either cannot survive or cannot reproduce in the short growing season. This study is selecting lines

of native grasses which are known to invade disturbances in subalpine and alpine areas. Selections are made on the basis of commercial potential and fitness for reclamation.

Status: The project is ongoing. More information is available in AEC annual reports.

Growth Performance of Commercial Timber Species in Reclamation - W.R. Dempster and Associates Ltd.

The purpose of Phase I of this study was to review and report, from available literature, growth performance data that could be used to develop standards expected of commercial timber species for reclaimed lands in the Eastern Slopes of Alberta. Phase II involved selection of a suitable growth performance, measure and field data collection in the Eastern Slopes.

Study parameters included:

1. Rates of juvenile growth, and appropriate measurement techniques and timing, required to provide reasonable assurance of successful reclamation;
2. The impact of site and cultural factors on growth performance, and the extent to which growth can be predicted from these factors;
3. Recommendations for the development of growth performance standards or guidelines including growth rate expectations, assessment methodology, the length of time required to assess performance, and the extent and acceptability of management inputs; and
4. Further research required to assist in the formation of growth standards and guidelines.

Status: The project is completed and the final report is under review.

Reclamation for Wildlife Habitat in the Mountains and Foothills of Alberta: Phase I: Literature Review, and Phase II: Wildlife Habitat Certification Handbook - J.E. Green, LGL Ltd.

Phase I of this study addressed: the synthesis of current information on habitat requirements of major wildlife species in the Mountains and Foothills of Alberta; an evaluation and collation of information on reclamation procedures for wildlife habitat; the applicability of these methods to Alberta; and, the development of criteria for the assessment of wildlife habitat reclamation procedures for certification purposes.

Phase II involved further evaluation of the literature on habitat assessment procedures. The information was used to develop models that could be used by field officers and mine planners to evaluate success of reclamation for a given habitat and key wildlife species.

Status: The project is completed. A report from the Phase I study has been published: RRTAC 86-9. The Phase II report is in press.

2.3 OIL SANDS RECLAMATION RESEARCH PROGRAM

In order to pool resources and avoid duplication of effort, RRTAC and industry initiated a joint research program in 1979. Priority research areas included woody plants (propagation, establishment and management) and soil reconstruction. In 1986, the program was expanded to include reclamation of tailings pond sludges.

Syncrude Canada Ltd. has been a very active supporter of this program providing research facilities and funds.

2.3.1 Reclamation Objectives

1. To develop techniques whereby a self-sustaining, erosion-free cover can be established on oil sand tailings pond dykes; and
2. To return tailings sand storage and overburden dumps to productive forest.

2.3.2 The Problem

Northeast Alberta contains all of Canada's surface-mineable oil sands. Extraction of this valuable petroleum resource presents several problems for reclamation. By far, the greatest problem lies with the tailings disposal systems currently employed.

At the end of its 25-year life, a typical oil sand plant producing 19 900 cubic meters per day (125 000 barrels per day) of synthetic crude oil will require a 22 to 31 square kilometer (8.5 to 12 square mile) tailings pond. The liquid contents of the pond will consist primarily of 360 million cubic meters of sludge. The sludge will remain in a liquid state indefinitely and will be impounded behind dykes built of tailings sand. Dyke heights will rearch from 55 to 100 meters above ground level. Erosion protection will be provided by a cover of grasses, legumes and shrubs. Because the tailings sand is devoid of nutrients and drains rapidly, amending materials (muskeg, certain mineral overburdens) will be added to begin development of a soil.

Pits left after mining will be filled with tailings sand and overburden dumps will be constructed. These sites will also be reclaimed to a designated land use. Soil reconstruction and woody plant establishment in particular need further research.

2.3.3 Research Approach

As in the mountains and foothills, proper reclamation in Northeast Alberta will produce landform and plant community combinations which will fulfill their land use requirements without indefinite maintenance.

The approach to revegetation is to identify the best woody species to plant in reclamation areas and to identify the best soil amendments for tailings sand. Biological (plant species) and physical (slope, sand/sludge mixtures, freeze/thaw cycles) methods for dewatering tailings pond sludge are also being investigated. By dewatering sludge, a material with considerably less volume and with better engineering (trafficability) properties is created.

2.3.4 Revegetation

Oil Sands Soil Reconstruction Project - H.E. Martens, Hardy BBT Limited.

Field trials were established on a 7 ha pad of tailings sand prepared by Syncrude Canada Ltd. on their property north of Fort McMurray. Various mixtures of peat and clay were incorporated to 20 and 40 cm depths. In 1984, the plots were planted with tree and shrub species to identify the best soil prescription for a particular forest cover type. Data are being collected each year on tree/shrub survival, growth and spread, and on soil moisture and soil nutrients.

Status: The project is ongoing.

Mycorrhizal Potential in Reconstructed Soils - B. Danielson, University of Calgary.

Mycorrhizal fungi nearly always enhance tree nutrition. This project has determined the survival and inoculum potential of mycorrhizal fungi in undisturbed and stockpiled peat to be used in oil sand tailing reclamation. Also, fungal species have been selected for use in jack pine seedling inoculation. Their effect on tree growth is being monitored in field trials.

Status: The project is completed and two final reports are in press. See RRTAC 84-4 for results of earlier studies.

Biological Dewatering of Oil Sand Tailings - R. Milner, Milner Engineering.

Work at AEC in 1985 demonstrated the ability of various plant species to dewater oil sand tailings sludge in 45-gallon drums to a point where the material was essentially solid. In 1986, RRTAC joined AEC and Syncrude Canada Ltd. in a small scale field test of this technology. Pits were constructed in Fort McMurray and filled with a mixture of tailing sludge, sand and lime and plants were introduced. Due to unforeseen problems, such as

pit flooding caused by a nearby dredge, the vegetation was unable to establish. However, valuable information on the physical behaviour of the sludge in larger tanks was obtained. Sludge was transported to Vegreville and placed in two pits on AEC property to observe the effects of a freeze/thaw cycle on moisture content.

This project had three objectives for 1987:

1. To compare biological (plant-induced evapotranspiration) and physical (evaporation alone) dewatering rates of pure sludge and sand-sludge mixes;
2. To measure the amount of dewatering of pure sludge that occurs as a result of freezing and thawing over winter; and
3. To design and construct surface drainage systems for sludge and sand-sludge mixes.

Three field experiments and numerous greenhouse and laboratory trials were established to meet the objectives. Field Experiment I is located on Syncrude property at Mildred Lake and consists of a comparison of dewatering capabilities of two plant species (reed canary grass and dock) versus an unplanted control (dewatering by evaporation alone) on two kinds of oil sand materials (pure sludge at 30% solids and 5:1 sand-sludge mixes at 55% solids) poured into grain bins (4.5 m diameter, 2 m depth).

Field Experiment II is a winter dewatering trial using freeze-thaw cycles on pure sludge in two pits. Pit 1 has a flat bed except for 30 cm ridges spaced 4 m apart. Pit 2 has the same ridges in the bottom but the entire pit bed is built on a 5% slope. The pits are approximately 50 m^2 in area and 2 m deep; 70 cm excavated below ground and 130 cm is dyked around the edges above ground. Each pit has two sand sections in the dyke to allow drainage. Both pits are lined with a polyethylene liner to prevent seepage. Both pits are instrumented with thermocouples at five depths (40 cm intervals) to monitor the freeze-thaw cycle. The pits were filled (150 to 200 cm) with 30% solids content sludge in October 1987 and allowed to freeze and thaw in winter and spring. After the surface water is gone (drained) samples for solids content will be taken, and a plant cover will be established on half of each pit (by mulch-seed treatment) to compare biological dewatering with evaporation.

Field Experiment III, a combination of winter and summer dewatering of pure sludge in trenches on AEC land, has now completed one year. The winter dewatering resulted in an increase from 30% to 50% solids. The summer dewatering, one half with reed canary grass and the other half unvegetated, dewatered the surface 10 cm to more than 80% solids and the uppermost 30 cm to more than 70% solids. Both treatments have dewatered the sludge sufficiently to have a bearing capacity capable of supporting man or machinery. Field Experiment III will be left overwinter to evaluate the hardiness of the reed canary grass and to see whether further dewatering will occur next summer.

Lab experiments evaluated response of reed canary grass on pure sludge to varying levels of fertilizer and the most efficient means of establishing plants on the fluid surface of the sludge.

Status: Work is ongoing. More details are available in AEC annual reports.

2.4 OIL AND GAS RECLAMATION RESEARCH PROGRAM

Conventional oil and gas deposits are found in all three biophysical regions noted above, while heavy oil deposits are found in the northeast. Since these disturbance types create similar reclamation concerns (disposal of drilling wastes, compaction, residual herbicides) regardless of biophysical region, a separate program was developed to co-ordinate research.

2.4.1 Reclamation Objectives

1. To develop environmentally-safe methods for disposal of drilling wastes (fluids and solids)
2. To return land to a condition capable of sustaining an approved land use.

2.4.2 The Problem

2.4.2.1 **Drilling wastes.** Three basic drilling muds and variations thereof are used for oil and gas exploration in Alberta. The freshwater gel bentonite

is most commonly used followed by the salt water systems which use sodium or potassium. The oil invert drilling mud is little used but is gaining in popularity. Diammonium phosphate (DAP) mud is being used in the Cold Lake region.

The wastes produced from drilling operations contain many complex organic and inorganic compounds that are added at various stages of the drilling process. The materials that start out as drilling mud are usually extensively altered chemically and physically by the time they enter a waste pit. The muds can be altered by heat and pressure effects associated with drilling and by the addition of drill cuttings brought up with the mud system. The materials found in the waste pit can also be changed chemically and physically by other products that are purposely or inadvertently added to the pit. Caustic soda rig wash, diesel fuel, waste oil from machinery, metal and plastic containers and other refuse often find their way into a waste pit.

The physical location of the waste pits must be carefully chosen to minimize the potential for subsurface spread of leachates generated from the drilling wastes. Knowledge of site characteristics such as: (1) the distance between the disposal site and the nearest surface water body, groundwater supply, or designated boundary, (2) the depth to the water table, (3) the water table gradient away from the site, and (4) the type and thickness of geologic material through which the contaminated water could migrate is required to make decisions on the suitability of a waste pit location. Knowledge of proposed waste pit contents and their likely effects on the permeability of pit liners is also important.

Drilling wastes are currently disposed of by burying, trenching, squeezing, and spreading. Each of these disposal methods impacts the environment in different ways. For example, interactions of waste constituents with groundwater is much more likely to occur if wastes are trenched or buried as opposed to surface spread. The reverse is true for soils and plants.

Review of the literature indicates that effects of disposal of drilling wastes on plants and soils varies with the type of waste, rate of application and plant species.

A thorough physical and chemical analysis of the liquid and solid phases of wastes generated by drilling operations utilizing the different mud types is one of the prerequisites to assessing potential environmental hazard of the disposal of these wastes and developing environmentally-safe disposal methods.

2.4.2.2 Compaction. A survey conducted by the Pipeline and Wellsite subcommittee of RRTAC found that Reclamation Officers perceived soil compaction to be the prime concern in reclaiming oil and gas wellsites. Repeated passage of heavy equipment during development and operating phases of a wellsite results in compaction of the soil. In some cases, seedbed preparation using conventional equipment does not appear to completely alleviate compaction. This results in poor growth of plants.

There is a lack of useful data pertaining to soil compaction in Alberta (and elsewhere), largely because a rapid, inexpensive and reasonably accurate measurement method has yet to be identified. Plant yield is one measure of compaction, however yield is affected by a wide array of other factors, notably management inputs. In addition, reclamation to an equivalent land capability rather than productivity is used to determine reclamation success by government officials, as yield is not a reliable short term measuring tool.

It is important to note that while wellsites were chosen for evaluation of compaction problems, any disturbance that involves the use of heavy equipment can produce compaction. Thus the results of this research may be applicable to pipelines, mines, sand and gravel pits, and forestry skid trails and loading zones among others.

2.4.2.3 **Residual Herbicides**. Soil sterilants, residual herbicides that render the treated soil unfit for plant growth for relatively long periods of time, are commonly used in Alberta on well sites, rights-of-way and other industrial areas for total vegetation control. Such vegetation control measures reduce fire hazards and improve aesthetic appearance. The treated areas can remain devoid of vegetation for many years depending upon the type and rate of soil sterilant used and the soil and climatic conditions. Furthermore, it is not uncommon to use more than the recommended rates of

these chemicals for achieving long-term vegetation control with a single application. Bromacil and tebuthiuron are the commonly used soil sterilants in Alberta.

Once the sterilant-treated site is abandoned, it may take several years before the site is restored to its original capability. The site also becomes a potential source of contamination through surface runoff and wind dispersion of soil sterilants onto adjoining untreated land. In Alberta, the extent of the soil sterilant problem is becoming apparent as more oil and gas lease sites are abandoned due to the marginal production value of many wells. The seriousness of the problem has been identified by various provincial organizations and committees.

2.4.3 Research Approach

In 1984, RRTAC sponsored a two-day workshop on drilling waste disposal in Alberta (RRTAC 87-3). The workshop identified a number of concerns that needed to be addressed.

As a result of this workshop, initial research focussed on trying to develop a manual that could be used by field staff to determine whether a waste could be safely spread on a given soil surface. The manual pointed to a need for detailed chemical characterization of sump fluids and solids before rational disposal decisions could be made. Thus, Phase I of the program has concentrated on getting chemical data from various drilling mud types in various regions of the province.

The approach to the compaction problem was to determine what characteristics predispose a soil to compaction and to identify the best field method for identifying and quantifying compaction. This knowledge will allow operators to avoid compaction wherever possible, and allow regulatory personnel to identify compacted areas.

The approach to the residual herbicide problem was to identify methods for binding the herbicide, thus rendering it ineffective.

2.4.4 Drilling Wastes

Disposal of Drilling Muds on the Public and Private Lands of Alberta - L. Leskiw, Pedology Consultants

This literature review evaluated options for drilling fluid disposal and indicated associated effects on soils and vegetation. Most primary disposal methods were identified and a field manual of disposal methods was developed. Areas regarding further research were identified. A technical review of existing guidelines was also conducted.

Status: Project is completed and a final report has been published: RRTAC 87-1.

Drilling Mud Disposal - T. Macyk, Alberta Research Council

The purpose of this project is to provide a scientific basis for development of guidelines for drilling mud solids disposal that optimizes environmental safety and cost effectiveness by carrying out problem analysis, and preliminary research to identify environmental limitations of available disposal technology. Drilling waste fluids and solids were collected from sumps at wellsites in Cold Lake (1986/87) using KCl, NaCl and freshwater muds, and the Eastern Slopes in 1987/88. Samples were collected at several depths and in several locations within a sump to determine spatial variability in chemistry. A suite of chemical analyses were performed to characterize both solids and fluids. Samples of sump solids were mixed at various rates with a soil indigenous to the region and planted to a grass species typically used in reclamation.

Status: Project is ongoing. Samples from Peace River/Grande Prairie wellsites will be collected in 1988 and the information for the three regions collated into a final report.

An Expert System for Siting Drilling Waste Sumps - A Feasibility Study - G.L. McClymont, Golder Associates Ltd.

Background: The placement of liquid and solid drilling wastes into sumps is one of the primary methods employed in Alberta for the ultimate disposal of these wastes. The wastes typically include hypersaline solutions (NaCl and KCl), organic compounds, heavy metals, and acidic and caustic solutions. Common to all sumps is the generation of a leachate that results from the interaction of the liquids and solids that comprise the waste material. The volume of leachate produced may be augmented by precipitation and groundwater that enter the sump. Leachate migrating from a sump may contain large concentrations of inorganic ions, particularly Na^+, K^+, and Cl^-, heavy metals and organic compounds with the potential to cause environmental damage to soil and aquifers. Consequently, the site at which a sump is to be constructed must be chosen carefully to avoid environmental problems.

Any methodology for selecting the sites of drilling waste sumps must consider the potential impact that the leachate could have on the local hydrogeology. However, the transport of the leachate in the subsurface will be governed by a complex set of physical, chemical and biological processes. Therefore, this component of the methodology requires a considerable amount of expertise in contaminant hydrogeology. At the present time in Alberta, the process of site selection may in some cases be conducted by industry and regulatory personnel who do not have extensive training in hydrogeology. Consequently, there is a perceived need for the development of some means of assisting these individuals with this aspect of site selection in order to optimize the quality of the decisions that they make.

Objective: The main objective of this study was to assess the feasibility of developing an expert system that will assist in the selection of sites for drilling waste sumps. The system would be developed for use by personnel from industry and government, and would operate on an IBM PC or a similar computer. Previous training in hydrogeology or in the operation of a computer would be advantageous, but neither would be a prerequisite for using the system.

Proposed Expert System: The development of an expert systems technique represents one of the most important successes that has come from research into artificial intelligence. Expert systems are designed to assist in solving lengthy or difficult problems in a user-friendly way. These systems have this capability because they contain the specific knowledge used by experts to solve a certain type of problem, and operate by applying this knowledge to the user's particular problem. Most systems include facilities that provide detailed descriptions of the problem-solving process and supporting information that will increase the user's understanding in the problem area. Consequently, an expert system will enhance a user's overall capabilities and productivity.

An expert's ability to solve complex problems comes from his or her extensive experience and highly specialized knowledge. The goal in building an expert system (a process referred to as knowledge engineering) is to extract and encode a sufficient amount of an expert's problem-solving knowledge so that others may solve the same problems. An expert's knowledge can be obtained from readily available sources such as textbooks, journals, manuals, conventional computer programs and data bases. In addition, information can be obtained directly from the expert through interviews. The information to be compiled includes factual data and heuristic (rule-of-thumb) knowledge. Heuristic knowledge is commonly a collection of simple observations, general beliefs and hunches, and insights into the best procedures for solving a problem.

In many instances, precise solutions to a problem based on factual data are not known or cannot be obtained easily. To cope with this situation, an expert will derive a solution by applying his or her heuristics. An expert system attempts to solve problems in the same way. That is, the system will resort to applying heuristic knowledge when factual data are not available. This approach reflects the main concept behind expert systems -- an expert system is designed to derive the same solution that an expert would reach.

The main components of the system would be a user/system interface and a set of contaminant transport models. To use the system, the user would first enter a set of information specific to the site under investigation. Assistance with this task would be provided by the system if requested. After

the information was entered, the system would select the contaminant transport model that best represented the hydrogeologic characteristics of the site. The model would then process the information. In the final step, the system would evaluate the model's results and provide the user with (a) information on the acceptability of the site, (b) reasons for rejecting a site if the system determined that it was unacceptable, (c) a statement on the system's degree of confidence in its assessment, and (d) for unacceptable sites, recommendations for making the site acceptable.

The system would contain many of the favourable features that are characteristics of, or are incorporated in, the traditional approaches to site selection as well as another expert system previously developed by the consultant. The system would also reflect a containment option strategy of waste management. Some of these attributes are as follows:

1. The system would be designed for use mainly by individuals with no previous training in hydrogeology or a related discipline. The use of hydrogeologic terminology would be kept to a minimum. Where this terminology has to be used, full definitions and explanations would be provided in lay terms.
2. Provisions would be made so that users with a background in hydrogeology could have full control of the data to be used by the transport models. These individuals would include personnel at Alberta Environment and hydrogeologists employed by industry.
3. Pre-screening criteria would be considered at the start of a session with the system. This part of the system would eliminate sites that possess features that are obviously unfavourable.
4. The system would require a minimum amount of site-specific data. The information that is needed would come from readily available sources.
5. The system would accommodate a variety of hydrogeologic settings. The transport models would account for the major transport processes (advection, dispersion, sorption and mass loss due to first-order reactions).

6. The system would provide clear-cut statements that would allow the user to easily assess the acceptability of a proposed site.
7. The system, rather than the user, would assign levels of confidence to the key hydrogeologic factors. The user would be informed of these confidence ratings and the basis on which they were assigned.
8. The system would be simple to use. Prior training in the use of a computer would be advantageous but it would not be required.
9. The user should be able to assess a site within a relatively short period of time, perhaps 30 minutes to one hour.

To ensure easy accessibility, the system will operate on an IBM PC (or compatible) computer.

Conclusions: The results of this study have shown that it is feasible to build an expert system to assist industry and regulatory personnel in the selection of sites for drilling waste sumps. The programming to implement the system architecture and to incorporate the favourable features of a site selection methodology can be written. These assessments are based on the success of a previous expert computer system. The three candidate transport models (ROKEY, DPCT and SUTRA) are public domain programs that are readily available. The results provided by the system should allow the users to easily assess the acceptability of a site for a drilling waste sump in terms of hydrogeologic considerations.

As with all expert systems, the most important aspect of system development is the availability of the problem-specific information. A large portion of the information for the system would be taken from the Expert ROKEY system. Due to the uniqueness of drilling wastes, additional information will have to be acquired either directly or by inference from the literature, and from industry and government sources. The direct participation of Alberta Environment, Alberta Forestry, Lands and Wildlife, and the Energy Resources Conservation Board would be needed for the preparation of performance and pre-screening criteria. The capabilities of the system would be greatly enhanced by obtaining site-specific hydrogeologic data for drilling waste sumps in the Province.

The cost of building the system is estimated to be in the order of $128 000. It is anticipated that approximately eight months would be required to complete the system. The estimated cost of collecting field data for testing and calibration is $40 000, bringing the cost of the project to a total of approximately $168 000. One alternative approach to system development is to construct the system in stages. The first stage could involve the construction of the system with one transport model (ROKEY) with the addition of the other two models in a subsequent stage. The estimated cost and time required for the first stage could be in the order of $99 000 and six months, respectively.

It is important to note one significant aspect of expert systems in terms of the cost of system development. In many instances, the programming and information components of an expert system can be used in other expert systems that are designed for similar tasks. Consequently, the cost of developing these "daughter" systems can be substantially less than if they were built "from scratch". For example, employing numerous programming and information components from the Expert ROKEY computer system will save tens of thousands of dollars and several months of development time. Similarly, the programming and information components developed for this system could be adapted for use in other expert systems. For example, these components could be used in an expert system for selecting sites for land spreading of drilling wastes, and in systems for selecting sites for the disposal of other wastes, such as brines and hazardous organic compounds.

Status: Project is finished. RRTAC is evaluating the need for further development of the system.

2.4.5 Compaction

Compaction on Oil and Gas Leases - L. Leskiw, Can-Ag Enterprises Ltd.

The concern in compaction-related reclamation research is measuring variables which can influence root development below the cultivated zone and

evaluating whether or not these variables are substantially different from those in nearby non-compacted soils.

Bulk density is most commonly used to determine soil compaction, but it shows considerable natural variation due to soil particle size distribution and organic matter content and has no unique value at which root growth is impeded. Hydraulic conductivity, porosity, air permeability, infiltration and sorptivity yield more valuable information, however, they are restricted from widespread use due to the considerable measurement time involved, the wide data variability, departure from normality and the absence of an exact relationship between these properties and plant growth.

Investigation of the relationship between soil mechanical strength, as measured by penetration resistance, and plant root growth indicates that a rapid, inexpensive measure of compaction may be available. Although soil strength is dependent on moisture content, texture, and soil fabric, the unambiguous relationship between soil strength, regardless of its cause, and root growth makes mechanical impedance a potentially valuable measurement of soil compaction.

Cone penetrometers are widely used for studies of soil trafficability and are now commonly used to measure soil compaction. The cone penetrometer has even been adopted by some for routine use in evaluating compaction problems in land reclamation. Perhaps slowing a more widespread use of penetrometers is a standardization problem. Penetrometer cones come in various shapes and sizes with results depending to some degree on the type of cone used. However, quantitative results from penetrometer cones of the same type produce consistent and comparable results. Penetrometer readings should be made at some standard soil moisture, preferably field capacity which would identify the strength of least resistance to root growth. In this regard, readings taken in spring, late fall, or after heavy rainfall may prove most valuable, although readings under drier conditions may have equal merit if reasonable caution is exercised.

This field survey project addressed four compaction concerns on east central oil and gas well sites:

1. The suitability of various methods of measuring compaction (soil strength, bulk density, morphology, porosity, pore size distribution) with regard to their sensitivity in detecting compaction, the number of samples necessary to adequately assess compaction, the time and cost involved, and the skill, equipment or facilities necessary to use the technique;
2. The extent of soil compaction both vertically and horizontally;
3. The degree of soil compaction on oil and gas well lease sites as compared to adjacent off-site areas; and
4. The nature of soil compaction with respect to how various soil properties are affected by the compaction process.

To accomplish these goals, a two-stage survey was conducted. A detailed survey concentrated on establishing appropriate sampling densities and on evaluating various techniques of measuring compaction.

At five sites, data were collected on soil strength (recording penetrometer), undisturbed cores were collected for measurement of bulk density and pore size distribution, disturbed or undisturbed cores were collected for measurement of moisture content, texture and organic matter, and soil profiles (for classification) and soil morphology (for the morphological compaction classification technique of McKeague et al. were recorded.

The second part of the survey involved an assessment of soil compaction on 20 sites using a recording penetrometer to measure vertical and horizontal soil compaction profiles. Emphasis was placed on strength measurements because they can be taken quickly, no expensive and time consuming laboratory work is required, and work at the Alberta Environmental Centre and elsewhere suggests that soil strength may be the variable most closely related to plant growth in compacted soils.

The information generated by this research should better determine the nature and scope of the compaction problem and will establish appropriate methods and sampling designs for future work concerning compaction on Alberta oil and gas leases.

Status: This phase of the compaction work is completed and a final report is in preparation. A field plot study designed to relate compaction level to crop growth is planned for 1988/89.

2.4.6 Efficiency of Activated Charcoal for Inactivation of Bromacil and Tebuthiuron Residues in Soil - Mr. E. Hemminger

A greenhouse study was conducted to investigate the efficiency of activated charcoal for inactivation of bromacil and tebuthiuron residues in soil as influenced by factors such as herbicide:activated charcoal ratio, soil texture, organic matter content, soil moisture and the time interval between activated charcoal incorporation and plant establishment. Oat (Avena fatus L.) was used as a bioassay species to assess the phytotoxicity of bromacil and tebuthiuron residues. Both herbicides were more phytotoxic when applied to sand or a mixture of sand + soil (1:1, w/w) as compared to a sandy clay loam soil.

Activated charcoal at rates up to 400 ppm in sand, soil or sand + soil mixture was not phytotoxic when incorporated without the herbicides. Incorporation of activated charcoal at rates ranging from 100 to 400 times the herbicide active ingredients (0.2, 0.8, and 2.0 ppm) protected oats, to varying degrees, from bromacil and tebuthiuron injury. The level of protection varied with the ratio of herbicide to activated charcoal and soil characteristics, mainly the organic matter and clay content. In general, nearly complete protection was achieved wnen the herbicide to activated charcoal ratio was 1:200 or more.

Protection of oats from bromacil or tebuthiuron injury improved as the time interval between activated charcoal incorporation and the seeding of oats increased from 0 to 1, 2 or 4 and 6 weeks. A time interval of at least one week was required for optimum binding of bromacil or tebuthiuron residues in soil by activated charcoal applied at a raio of 1:100 (herbicide:activated charcoal). A shorter interval was required at a ratio 1:400.

Injury to oat plants from bromacil or tebuthiuron decreased as the soil moisture level decreased. Protection of oat plants from herbicide injury by activated charcoal, especially at lower herbicide:activated charcoal ratios, was slightly better under the lower moisture regimes than at the high moisture regime. This difference was considered due to an increased activity of bromacil and tebuthiuron under optimum moisture conditions rather than a direct effect of low moisture regimes on the efficiency of activated charcoal on herbicide inactivation.

Results of this greenhouse study showed that activated charcoal, at ratios of 1:200 or more (herbicide active ingredient:activated charcoal) can be effectively used to inactivate bromacil and tebuthiuron residues in soil. The efficiency of activated charcoal ratios, soil characteristics (texture, organic matter content and moisture level) and the time interval between activated charcoal incorporation and plant establishment.

Status: Project is finisned. The final report is being prepared.

3.1 PREVIOUS RESEARCH

PROBLEM AREA	RESEARCH PRIORITIES	DESCRIPTION
Program: Plains Coal Reclamation Research Program		
Objective: Restoration of Agricultural Capability		
Groundwater/ Geology	- Effects of mining on groundwater supplies - Generation of salts in spoil - Transport of salts near the reclaimed soil surface - Subsidence after reclamation - Overburden classification	The regions including and surrounding the Battle River and Highvale Mining areas are being intensively monitored to assess the effects of mining on the soil, water and ultimately, the agricultural resources. As significant concerns are identified remedial measures are also evaluated. Phases I and II of the hydrology project are completed. The long-term effects of subsidence, salinization and soil quality are being monitored. See RRTAC Reports 80-3, 86-2, 86-3, 86-4, 86-5, 86-6, 86-7, 87-9, 87-10, 87-11, 87-12, 87-13.
Soil Reconstruction	- Thickness of subsoil required above sodic spoil - Effects of slope on lateral salt transport - Reconstruction of Solonetzic soils - Use of bottom ash as soil amendment - Effects of crop type - Changes in topsoil during stockpiling	Experimental plots have been constructed on the Battle River and Highvale Mine areas and 1987 will be their sixth and fifth crop years, respectively. The plots will be intensively monitored annually for at least five crop years each. An experiment to test optimum amounts of bottom ash and incorporation methods has been completed. See RRTAC Report 87-7.
Fly and Bottom Ash Disposal	- Chemical and physical properties of Alberta fly and bottom ashes - Potential for use as soil amendment	Ashes from five Alberta sources were analyzed for both toxicity and soil amendment possibilities. This work is completed and the results are published in RRTAC Report 81-3.

PROBLEM AREA	RESEARCH PRIORITIES	DESCRIPTION
Program: Mountains and Foothills Reclamation Research Program		
Objective: Restoration of Forestry, Wildlife and Watershed Capabilities		
Landscape Design	Design and construction of stable spoil dumps	A survey was conducted of existing reclaimed dumps in Alberta and British Columbia to identify practical resloping strategies. A study of erosion of a variety of dump slopes was conducted. See RRTAC Report 87-8.
	Water management	Settling pond size requirements, the scientific basis for water quality objectives, and methods for predicting sediment production were reviewed and evaluated. See RRTAC Report 86-1.
Soil Reconstruction	For various land uses	A literature review and evaluation of soil reconstruction requirements was completed. See RRTAC Report 87-2.
	For erosion control on ash dumps	Thickness of soil required over coal ash to support vegetation was investigated.
	Species selection	Development, assessment and field testing of native grasses for reclamation is ongoing.
Revegetation	Propagation	Methods for propagation of reclamation shrubs were assesed.
	Establishment	Methods for establishment of tree seedlings in grass cover were evaluated.
	Fertilization, nutrients	Studies identified treatments important to development of self-sustaining plant cover.

PROBLEM AREA	RESEARCH PRIORITIES	DESCRIPTION
Revegetation (Cont.)	Erosion control	Mulches, binders and contouring techniques for erosion control on coal spoil were evaluated.
	Wildlife Habitat	A literature review of methods for wildlife habitat reclamation was completed. See RRTAC Report 86-9.
Program: Oil Sands Reclamation Research Program		
Objective: Restoration of Forestry, Wildlife Capabilities and Erosion Control		
Soil Reconstruction on Tailings	Identify recipes for reconstructed soils suitable for: - Commercial forest - Non-commercial forest - Erosion control - Wildlife habitat	Identification of the chemical and microbiological properties of peat, development of mycorrhizal innoculants for jack pine and other woody species, identification of amendment level requirements. The earlier studies are largely complete and were fundamental in designing the oil sand soil reconstruction plots which were constructed in 1983. See RRTAC Reports 83-1 and 84-4.
Revegetation	- Selection - Propagation - Establishment - Management - Sampling	These projects consist of literature reviews on tree and shrub selection, seed collection, propagation techniques, and sampling methods for use on the soil reconstruction plots. See RRTAC Reports 83-5 and 84-2.
Program: Oil & Gas Reclamation Research Program		
Objective: To develop safe methods of waste disposal and return land to a condition capable of sustaining a designated land use.		
Materials Handling	Identify the best methods for handling soil materials in pipeline construction in agricultural land	A survey was made of pipelines of various ages on all of our major agricultural soil types. Material handling methods were assessed and problem areas identified. See RRTAC Report 83-3.

PROBLEM AREA	RESEARCH PRIORITIES	DESCRIPTION
Drilling Muds	Disposal of drilling muds	A literature review of disposal methods for KCl drilling muds was undertaken. See RRTAC Report 87-1.
Program: General*		
Reclamation Bibliography and Review	Document the findings of reclamation research activities and assess implications for Alberta operations	Worldwide reclamation literature has been reviewed and condensed for presentation in a report which lists and discusses existing information pertinent to reclamation in Alberta. The data base is accessable through the University of Alberta computing system. See RRTAC Reports 82-1 and 84-1.
Workshops	Conduct workshops to determine research needs in Alberta and to disseminate research findings	See RRTAC Reports 80-4 (Forest Soils), 81-3 (Coal Ash), 83-4 (Eastern Slopes Hydrology), 85-1 (Revegetation in Mountains/Foothills) and 87-3 (Gel and Saline Drilling Wastes)
Reference	Provide sources of information for reclamationists	See RRTAC reports 80-5 (Plant Species Manual), 81-2 (Survey of Activities), and 82-2 (Bibliography of Soils, Geology, Hydrology and Groundwater).

* Projects with province-wide application.

3.2 1987/88 RECLAMATION RESEARCH BUDGET

Project No.	Project	1987/88 Budget ($)
PLAINS COAL RECLAMATION RESEARCH PROGRAM		
78-20	Can-Ag Enterprises Ltd. Battle River Soil Reconstruction Project	130 000.00
82-24	Monenco Consultants Ltd. Highvale Soil Reconstruction Project	160 000.00
86-39	Milner Engineering Water Balance in Sodic Spoil	30 000.00[1]
OIL SANDS RECLAMATION RESEARCH PROGRAM		
83-07	Hardy BBT Limited Oil Sand Soil Reconstruction Project	45 000.00[2]
86-39	Milner Engineering Biological Dewatering of Sludge	41 000.00[3]
OIL & GAS RECLAMATION RESEARCH PROGRAM		
86-32A	Can-Ag Enterprises Ltd. Soil Compaction	15 000.00[4]
86-33	Alberta Research Council Drilling Mud Disposal	50 000.00[5]
87-23	Mr. E. Hemminger Efficiency of Activated Charcoal for Inactivation of Bromacil and Tebuthiuron Residues in Soils	8 400.00

Continued . . .

1987/88 RECLAMATION RESEARCH BUDGET. CONCLUDED.

87-24	Golder Associates (Western Canada) Ltd. An Expert System for Siting Drilling Waste Sumps - A Feasibility Study	20 600.00

TOTAL RRTAC	$ 500 000.00
TOTAL CO-FUNDING AGENCIES	224 145.00
GRAND TOTAL	$ 724 145.00

Co-funding Agencies

1 Alberta Environmental Centre ($30 000)
2 Syncrude Canada Ltd. ($21 000)
3 Alberta Environmental Centre ($98 450), Syncrude Canada Ltd. ($31 570)
4 Alberta Environmental Centre ($16 000)
5 Alberta Research Council ($26 945)

RRTAC funds are provided by the Alberta Heritage Savings Trust Fund.

3.3 LAND CONSERVATION AND RECLAMATION COUNCIL

Mr. J.M. King	Alberta Environment, Chairman
Mr. D. Fregren	Alberta Forestry, Lands and Wildlife Alberta Forest Service Deputy Chairman
Mr. M.G. Turnbull	Alberta Forestry, Lands and Wildlife Public Lands Division Deputy Chairman

3.4 RECLAMATION RESEARCH TECHNICAL ADVISORY COMMITTEE (RRTAC)

Dr. G.A. Singleton, Chairman

Ms. S. Guenette, Secretary

Mr. C.B. Powter, Project Manager

Alberta Agriculture	Alberta Forestry, Lands and Wildlife	Alberta Environment	Alberta Research Council
Mr. L.C. Marciak Conservation and Development	Mr. T.J. Drew Alberta Forest Service	Mr. R. Hermesh Alberta Environmental Centre	Dr. S.R. Moran Terrain Sciences
	Mr. D.G. Lloyd Public Lands		
	Mr. H. Wollis Fish and Wildlife		

3.5 RECLAMATION RESEARCH REPORTS

** 1. RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp.

DESCRIPTION: This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

** 2. RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi and H.F. Regier. 160 pp.

DESCRIPTION: Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

** 3. RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. 2 vols. L.E. Watson, R.W. Parker and P.F. Polster. 541 pp.

DESCRIPTION: Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their fitness for use in Reclamation. Range maps, growth habit, propagation, tolerance and availability information are provided.

NA 4. RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp.

DESCRIPTION: This survey is an update of the original report conducted in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

NA 5. RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stien, R. Leitch and G. Lutwick. 253 pp.

DESCRIPTION: Presents nine technical papers on the chemical, physical and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites and use of ash as a soil amendment. Workshop discussions and summaries are also included.

NA 6. RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols. 292 pp.

DESCRIPTION: Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system. Vol. 2 comprises the keyword index and computer access manual.

NA 7. RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp.

DESCRIPTION: This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981 are available from the Alberta Environment Library.

NA 8. RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp.

DESCRIPTION: Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of recently initiated field trials.

NA 9. RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp.

DESCRIPTION: Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop reproduction.

NA 10. RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz. 123 pp.

DESCRIPTION: Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics and resulting water quality. Mitigative measures and priorities were also discussed.

NA 11. RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp.

DESCRIPTION: This is a review and analysis of information on planting stock quality, rearing site preparation, planting and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

NA 12. RRTAC 84-1: Land Surface Reclamation: A Review of International Literature. H.P. Sims, C.B. Powter and J.A. Campbell. 2 vols. 1549 pp.

DESCRIPTION: Nearly all topics of interest to reclamation including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

** 13. RRTAC 84-2: Propagation Study: Use of Trees and Snrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp.

DESCRIPTION: This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

* 14. RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 15. RRTAC 84-4: Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser and J.C. Zak. 2 vols. 676 pp.

DESCRIPTION: This is a collection of five reports dealing with reestablishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

** 16. RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz. 416 pp.

DESCRIPTION: Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling shrub propagation and establishment are presented.

* 17. RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 18. RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp.

DESCRIPTION: The report examines the critical issue of settling pond design and sizing and alternative technologies. An executive summary outlines the findings.

** 19. RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp.

DESCRIPTION: Reconstructed soils representing different materials handling and replacement techniques were characterized and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered

by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

* 20. RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp.

DESCRIPTION: In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

** 21. RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp.

DESCRIPTION: This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

** 22. RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Program.
A. Maslowski-Schutze. 71 pp.

DESCRIPTION: This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

* 23. RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project.
M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp.

DESCRIPTION: The report deals with the availability of water supply in or beneath cast overburden at the Battle River Mining area in east-central Alberta to support post-mining land use. Both groundwater quantity and quality are evaluated.

* 24. RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project.
M.R. Trudell. 25 pp.

DESCRIPTION: This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

* 25. RRTAC 86-8: Reclamation Research Annual Report - 1985.
P.F. Ziemkiewicz. 54 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

** 26. RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp.

DESCRIPTION: This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed.

** 27. RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp.

DESCRIPTION: Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual included provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

** 28. RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik and D.G. Walker. 174 pp.

DESCRIPTION: This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area.

** 29. RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (compiler). 218 pp.

DESCRIPTION: Technical papers were presented which describe: the mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

* 30. RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp.

DESCRIPTION: This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results and expenditures.

* 31. RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp.

DESCRIPTION: The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the east slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed.

** 32. RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp.

DESCRIPTION: The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersneds disturbed by surface mining and is well suited to Alberta conditions.

* 33. RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp.

DESCRIPTION: The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from a nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

* 34. RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chopiuk and S.E. Thornton. 45 pp.

DESCRIPTION: This report describes a study to evaluate the influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

** 35. RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Area. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp.

DESCRIPTION: This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

** 36. RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus maps.

DESCRIPTION: The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area.

Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. A series of maps supplement the report.

** 37. RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp.

DESCRIPTION: This report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

** 38. RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp.

DESCRIPTION: This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

* 39. RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp.

DESCRIPTION: This report provides the rationale and a system for assessing the agricultural capability of reconstructed

soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

** 40. RRTAC 88-1: A Proposed Evaluation System for Wildlife Habitat Reclamation in the Mountains and Foothills Biomes of Alberta: Proposed Methodology and Assessment Handbook. T.R. Eccles, R.E. Salter and J.E. Green. 101 pp. plus appendix.

DESCRIPTION: The report focuses on the development of guidelines and procedures for the asessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The technical section provides background documentation including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook section contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be used by site operators and reclamation officers.

** 41. RRTAC 88-2: Plains Hydrology and Reclamation Project: Spoil Groundwater Chemistry and its Impacts on Surface Water. M.R. Trudell (Compiler). 135 pp.

DESCRIPTION: Two reports comprise this volume. The first report, "Chemistry of Groundwater in Mine Spoil, Central Alberta," describes the chemical make-up of spoil groundwater at four mines in the Plains of Alberta. It explains the nature and magnitude of changes in groundwater chemistry following mining and reclamation. The second report, "Impacts of Surface Mining on Chemical Quality of Streams in the Battle River Mining Area," describes the chemical quality of water in streams in the Battle River mining area, and the potential impact of groundwater discharge from surface mines on these streams.

** 42. RRTAC 88-3: Revegetation of Oil Sands Tailings: Growth Improvement of Silver-berry and Buffalo-berry by Inoculation with Mycorrhizal Fungi and N_2-Fixing Bacteria. S. Visser and R.M. Danielson. 98 pp.

DESCRIPTION: The report provides results of a study: (1) To determine the mycorrhizal affinities of various actinorrhizal shrubs in the Fort McMurray, Alberta region; (2) To establish a basis for justifying symbiont inoculation of buffalo-berry and silver-berry; (3) To develop a growing regime for the greenhouse production of mycorrhizal, nodulated silver-berry and buffalo-berry; and (4) To conduct a field trial on reconstructed soil on the Syncrude oil sands site to critically evaluate the growth performance of inoculated silver-berry and buffalo-berry as compared with their uninoculated counterparts.

** 43. RRTAC 88-4: Plains Hydrology and Reclamation Project: Investigation of the Settlement Behaviour of Mine Backfill. D.R. Pauls (compiler). 135 pp.

DESCRIPTION: This three-part volume covers the laboratory assessment of the potential for subsidence in reclaimed landscapes. The first report in this volume, "Simulation of Mine Spoil Subsidence by Consolidation Tests," covers laboratory simulations of the subsidence process particularly as it is influenced by resaturation of mine spoil. The second report, "Water Sensitivity of Smectitic Overburden: Plains Region of Alberta" describes a series of laboratory tests that have been used to determine the behaviour of overburden materials when brought into contact with water. The report entitled, "Classification System for Transitional Materials: Plains Region of Alberta" describes a lithological classification system developed to address the characteristics of the smectite rich, clayey transition materials that make up the overburden in the Plains of Alberta.

** 44. RRTAC 88-5: Ectomycorrhizae of Jack Pine and Green Alder: Assessment of the Need for Inoculation, Development of Inoculation Techniques, and Outplanting Trials on Oil Sand Tailings. R.M. Danielson and S. Visser. 177 pp.

DESCRIPTION: The overall objective of this research was to characterize the mycorrhizal status of jack pine and green alder which are prime candidates as reclamation species for oil sand tailings and to determine the potential benefits of mycorrhizae on plant

performance. This entailed determining the symbiont status of container-grown nursery stock and the quantity and quality of inoculum in reconstructed soils, developing inoculation techniques and finally, performance testing in an actual reclamation setting.

Available from: Publication Services, Queen's Printer, 11510 Kingsway Avenue, Edmonton, Alberta T5G 2Y5

* A $5.00 fee is charged for handling and postage.
** A $10.00 fee is charged for handling and postage.
*** A $20.00 fee is charged for handling and postage.
NA Not available for purchase, but can be reviewed at the Alberta Environment Library, 14th Floor, 9820 - 106 Street, Edmonton, Alberta

Please make cheque payable to: "Provincial Treasurer of Alberta"